**Genetics Problems: Dihybrid Crosses**

Punnett squares can be used to predict the possible genotypes of the offspring from two parents. Punnett square in which only one gene is considered at called **monohybrid crosses.** However, these can be extended to crosses involving two genes which affect two traits.

*Step 1: Determine the genotypes of the parents*

*Step 2: Determine the gametes*

*Step 3: Create a Punnett square*

**Multiple Choice Question 1**

If you cross a BbDd female cat with a bbDd male where the relationship between allele and phenotype is:

B = black, b = brown, D = full colour, d = dilute, the phenotypic ratio will be:

1. 3:3:1:3
2. 5:5:5:1
3. 7:4:3:2
4. 9:3:3:1

**Short Answer Question 1**

Mendel found that in pea plants tall was dominant to dwarf. He also discovered that plants with white flowers only produced plants with white flowers while plants with coloured flowers could produce offspring with white or coloured flowers.

1. How many genes are involved here and what do they code for?
2. Assign symbols to each of the four alleles mentioned.
3. A pure breeding tall plant with coloured flowers is crossed with a dwarf, white flowered plant.
4. Give the genotypes for both plants
5. Give the F1 genotype(s) and phenotype(s)
6. Create a Punnett square to determine the F2 genotypes
7. List the genotypes present and the proportion of each
8. Identify the phenotypes present and give the proportion of each
9. Do the phenotype ratios above apply to all crosses from pure breeding parents? Explain (assume the genes are not linked).

**Short Answer Question 2**

The coat colour of Duroc-Jersey pigs is determined by two independent genes (R-r and S-s). At least one dominant allele from each gene must be present if a pig is to have a full red coloured coat. If only one dominant allele is present from either of the genes a sandy coat colour results. Animals which are homozygous recessive for both genes have a white coat.

* 1. A pure-breeding red pig is crossed with a white pig. Identify the possible genotype(s) and phenotype(s) of the offspring.
  2. Complete a Punnett square to determine the offspring from a cross of F1 offspring.
  3. What are the phenotype ratios?
  4. How would you modify your answer to question 1 c vi in light of this example?

**Short Answer Question 3**

Tall-stemmed garden peas (T) with rounded seeds (R) crossed. Assume the tall-stemmed, round seed plants are double heterozygotes. Determine the correct genotypic and phenotypic ratios for the F1 generation.

**Short Answer Question 4**

Tall stem (T) is dominant to short stem (t) and coloured seed-coat (L) is dominant to colourless seed-coat (l). Cross double heterozygotes with double homozygous recessives. Determine the correct genotypic and phenotypic ratios for the F1 generation.

**Short Answer Question 5**

For the same traits as above, a cross of tall, colourless seed-coat plants with short, coloured seed-coat plants produced offspring in the following phenotypic ratio: ½ tall, colourless: ½ short, coloured. What were the genotypes of the parent plants (show working out)?

**Short Answer Question 6**

In rabbits, spotted coat (S) is dominant to solid colour (s), and black (B) is dominant to brown (b). These loci are unlinked. A brown spotted rabbit from a pure line is mated to a solid black one, also from a pure line.

1. What are the genotypes of the parents?
2. What would be the genotype and phenotype of an F1 rabbit?
3. What would be the expected genotypes and phenotypes in the F2 generation?

**Short Answer Question 7**

In cats, two unlinked genes and their alleles are:

Gene 1 L = short hair, l = long hair

Gene 2 B = black hair, b = brown hair

1. A cat, heterozygous at both gene loci was crossed with a cat homozygous for short brown hair. What genotypes and respective phenotypes would you expect in the offspring?
2. What genotypes and respective phenotypes would you expect in the offspring of a cross between two cats heterozygous at both loci?

**Answers**

**Multiple Choice Question 1**

A

|  |  |  |
| --- | --- | --- |
|  | bD | bd |
| BD | BbDD | BbDd |
| Bd | BbDd | Bbdd |
| bD | bbDD | bbDd |
| bd | bbDd | bbdd |

Black – BbDD, BbDd, BbDd

Brown – bbDd, ddDd, bbDd

Dilute black – Bbdd

Dilute brown - bbdd

**Short Answer Question 1**

###### a. Two genes: one for height and one for colour

###### b. T = tall and t = dwarf C = coloured and c = white

c. i.TTCC x ttcc

c. ii.P: TTCC x ttcc

Gametes: TC and tc

F1: 100% TtCc; 100% Tall Coloured

c. iii.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | TC | Tc | tC | tc |
| TC | TTCC | TTCc | TtCC | TtCc |
| Tc | TTCc | TTcc | TtCc | Ttcc |
| tC | TtCC | TtCc | ttCC | ttCc |
| tc | TtCc | Ttcc | ttCc | ttcc |

c iv. TTCC – 1/16 TtCC – 2/16 = 1/8 ttCC – 1/16

TTCc – 2/16 = 1/8 TtCc – 4/16 = ¼ ttCc – 2/16 = 1/8

TTcc – 1/16 Ttcc – 2/16 = 1/8 ttcc – 1/16

c. v. Tall coloured – 1/16 + 2/16 + 2/16 + 4/16 = 9/16

Tall white – 1/16 + 2/16 = 3/16

Dwarf coloured – 1/16 + 2/16 = 3/16

Dwarf white – 1/16

c. vi. No – pure breeding could be TTCC x TTCC or ttcc x ttcc, in which case all offspring would be the same. If TTCC is always crossed with ttcc, these ratios are always expected where there is a large sample size – however, this doesn’t mean they’ll always be obtained.

**Short Answer Question 2**

R \_ S \_ = red

R \_ ss = sandy

rrss = white

a. Parents: RRSS x rrss

Gametes: RS and rs

F1: RrSs

b.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | RS | Rs | rS | rs |
| RS | RRSS | RRSs | RrSS | RrSs |
| Rs | RRSs | RRss | RrSs | Rrss |
| rS | RrSS | RrSs | rrSS | rrSs |
| rs | RrSs | Rrss | rrSs | rrss |

c. Red – 9/16 Sandy – 6/16 = 3/8 White – 1/16

d. One gene must be dominant over the other, and only a single gene determines one characteristic.

**Short Answer Question 3**

Parents: TtRr x TtRr

Gametes: TR, Tr, tR, tr for both parents

Genotypic Ratio: 1 TTRR : 2 TTRr : 2 TtRR : 4 TtRr : 1 TTrr : 1 ttRR : 2 Ttrr : 1 ttRr : 1 ttRr : 1 ttrr

Phenotypic Ratio: 9 tall axial : 3 tall terminal : 3 short axial : 1 short terminal

**Short Answer Question 4**

Parents: TtLl x ttll

Gametes: TL, Tl, tL, tl and tl

Genotypic Ratio: 1 TtLl : 1 Ttll : 1 ttLl : 1 ttll

Phenotypic Ratio: 1 tall coloured : 1 tall colourless : 1 short coloured : 1 short c colourless

**Short Answer Question 5**

Parents (info given in Q): T \_ ll x tt L \_

To produce short offspring, 1st parent must be Ttll

P: Ttll x ttLl

To produce colourless offspring, 2nd parent must be ttLl

Therefore, parents: Ttll x ttLl

**Short Answer Question 6**

a. Parents – bbSS x BBss

b. F1 Genotype – BbSs F1 Phenotype – Black Spotted

c. F2:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | BS | Bs | bS | bs |
| BS | BBSS | BBSs | BbSS | BbSs |
| Bs | BBSs | BBss | BbSs | Bbss |
| bS | BbSS | BbSs | bbSS | bbSs |
| bs | BbSs | Bbss | bbSs | bbss |

Genotypic Ratio – 1 BBSS : 2 BBSs : 2 BbSS : 4 BbSs : 1 BBss : 2 Bbss: 1 bbSS : 2 bbSs : 1 bbss

Phenotypic Ratio – 9 Spotted black : 3 Spotted brown : 3 Solid black : 1 Solid brown

**Short Answer Question 7**

a. Parents: LlBb x LLbb

Gametes: LB, Lb, lB, lb and Lb

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | LB | Lb | lB | Lb |
| Lb | LLBb | LLbb | LlBb | LLbb |

Genotypes: 1 LLBb, 2 LLbb, 1 LlBb

Phenotypes: 2 short black, 2 short brown

b. Parents: LlBb x LlBb

Gametes: LB, Lb, lB, lb

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | LB | Lb | lB | lb |
| LB | LLBB | LLBb | LlBB | LlBb |
| Lb | LLBb | LLbb | LlBb | Llbb |
| lB | LlBB | LlBb | LlBB | LlBb |
| lb | LlBb | Llbb | LlBb | llbb |

Phenotypes: 9 long black: 3 long brown: 3 short brown: 1 long brown